PATENT ABSTRACTS OF JAPAN

(11)Publication number : 11-154389
(43)Date of publication of application : 08.06.1999

(51)Int.Cl. G11C 11/15

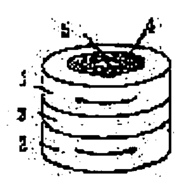
(21)Application number : 10-256965
(22)Date of filing : 10.09.1998

(71)Applicant : CANON INC
(72)Inventor : NISHIMURA NAOKI

(30)Priority
Priority number : 09253531 Priority date : 18.09.1997 Priority country : JP

(54) MAGNETORESISTIVE ELEMENT, MAGNETIC THIN FILM MEMORY ELEMENT, AND RECORDING AND REPRODUCING METHOD FOR THE MEMORY ELEMENT

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a magnetic thin film element, a magnetic thin film memory element, and a recording and reproducing method for this memory element in which a preservation state of magnetic information is high, high integration and reliability can be realized, stable recording/reproduction can be performed, manufacturing margin of a non-magnetic layer is wide, a reproducing time is short, and a reproducing method having less noise cn be realized.



SOLUTION: A first magnetic layer 1 having closed magnetic path structure and a low coercive force a second magnetic layer 2 having closed magnetic path structure and a high coercive force are laminated through a non-magnetic layer 3 consisting of insulators 4, the first magnetic layer 1 and the second magnetic layer 2 have easy shafts of CCW or CW, and they have different resistance depending on a relative angle of the magnetization direction of the first and the second magnetic layers 1, 2.

LEGAL STATUS

[Date of request for examination]	18.12.2002
[Date of sending the examiner's decision of rejection]	18.01.2006
[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]	
[Date of final disposal for application]	
[Patent number]	
[Date of registration]	
[Number of appeal against examiner's decision of rejection]	
[Date of requesting appeal against examiner's decision of rejection]	
[Date of extinction of right]	

(19)日本国特許庁（ＪＰ） (12) 公開特許公報(A) (11)特許出願公開番号

特開平11−154389

(43)公開日 平成11年(1999) 6月8日

(51)Int.Cl.⁶ 識別記号 ＦＩ
Ｇ１１Ｃ 11/15 Ｇ１１Ｃ 11/15

審査請求 未請求 請求項の数13 ＯＬ （全 8 頁）

(21)出願番号 特願平10−256965

(22)出願日 平成10年(1998) 9月10日

(31)優先権主張番号 特願平9−253531

(32)優先日 平9 (1997) 9月18日

(33)優先権主張国 日本（ＪＰ）

(71)出願人 000001007
キヤノン株式会社
東京都大田区下丸子３丁目30番２号

(72)発明者 西村 直樹
東京都大田区下丸子３丁目30番２号 キヤノン株式会社内

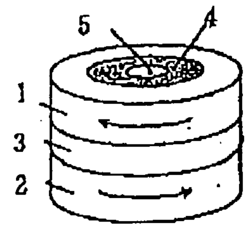
(74)代理人 弁理士 若林 忠 （外４名）

(54)【発明の名称】 磁気抵抗素子、磁性薄膜メモリ素子および該メモリ素子の記録再生方法

(57)【要約】

【課題】 磁化情報の保存性高く高い集積度と信頼性を実現でき、安定した録再ができ、非磁性層の製造マージンが広く、再生時間が短く、ノイズの少ない再生方法を実現できる磁性薄膜素子、磁性薄膜メモリ素子および該メモリ素子の記録再生方法を提供する。

【解決手段】 基板上に、閉磁路構造で低い保磁力を有する第一磁性層１と、閉磁路構造で高い保磁力を有する第二磁性層２が、絶縁体４からなる非磁性層３を介して積層され、該第一磁性層１および該第二磁性層２は左回りもしくは右回りに容易軸を有し、該第一、第二磁性層の磁化方向の相対角度によって、異なる抵抗値を有することを特徴とする。



.

CLAIMS

[Claim(s)]
[Claim 1] It is the magnetic resistance element characterized by carrying out a laminating on a substrate through the 1st magnetic layer which has low coercive force with closed magnetic circuit structure, and the non-magnetic layer which the 2nd magnetic layer which has high coercive force with closed magnetic circuit structure turns into from an insulator, and for this 1st magnetic layer and this 2nd magnetic layer having an easy shaft left-handed rotation or in the clockwise direction, and having the resistance which changes with whenever [angular relation / of the magnetization direction of this 1st and 2nd magnetic layer].
[Claim 2] The magnetic-thin-film memory device characterized by consisting of a magnetic resistance element according to claim 1.
[Claim 3] The magnetic-thin-film memory device according to claim 1 in which the 1st magnetic layer and the 2nd magnetic layer contain at least one sort of elements among Fe, Co, and nickel.
[Claim 4] The magnetic resistance element according to claim 1 said whose non-magnetic layer is an aluminum oxide, alumimium nitride, silicon oxide, or silicon nitride.
[Claim 5] The magnetic resistance element according to claim 1 the thickness of the 1st magnetic layer and the 2nd magnetic layer exceeds 100A, and is [magnetic resistance element] 5000A or less.
[Claim 6] The thickness of said non-magnetic layer is 5A or more a magnetic resistance element which is 30A or less according to claim 1.
[Claim 7] The magnetic resistance element according to claim 1 to which the coercive force of the 10 or more Oes 50 or less Oe and the 2nd magnetic layer exceeds [the coercive force of said 1st magnetic layer / the coercive force of the 1st magnetic layer] 50Oe(s) below in one half of the coercive force of said 2nd magnetic layer.
[Claim 8] The magnetic resistance element according to claim 1 to which the antiferromagnetism layer is prepared in contact with the non-magnetic layer of said 2nd magnetic layer, and the field of the opposite side, this antiferromagnetism layer and this 2nd magnetic layer carry out switched connection, and magnetization of this 2nd magnetic layer is being fixed.
[Claim 9] The magnetic resistance element according to claim 1 by which the conductor surrounded by the insulator is formed in the core of the 1st magnetic layer and the 2nd magnetic layer.
[Claim 10] For the coercive force of the 10 or more Oes 50 or less Oe and the 1st magnetic layer, the coercive force of said 2nd magnetic layer is the magnetic resistance element according to claim 1 it is 2 or more Oes and is [magnetic resistance element] below one half of the coercive force of the 2nd magnetic layer.
[Claim 11] The record approach of the magnetic-thin-film memory characterized by recording the condition of "0" and "1" by setting the magnetization direction of said 1st magnetic layer to said magnetic-thin-film memory device by the field which produces a current according to a sink this current in a film surface and a perpendicular.
[Claim 12] The record approach of the magnetic-thin-film memory device characterized by recording the condition of "0" and "1" by setting the magnetization direction of said 2nd magnetic layer to said

magnetic-thin-film memory device by the field which produces a current according to a sink this current in a film surface and a perpendicular.
[Claim 13] The playback approach of the magnetic-thin-film memory characterized by detecting the magnetization information on "0" and "1" by measuring sink resistance for a current to said magnetic-thin-film memory device at a film surface and a perpendicular.

[Translation done.]

* NOTICES *

JPO and NCIPI are not responsible for any damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention records information with the sense of magnetization, and relates to the magnetic-thin-film memory using the magnetic resistance element and it which are reproduced according to a magneto-resistive effect.
[0002]
[Description of the Prior Art] Although magnetic-thin-film memory is solid-state memory which does not have the operation section as well as semiconductor memory, even if a power source is severed, when an infinity time and a radiation carry out [the count of repeat rewriting which does not lose information] incidence, there is an advantageous point as compared with semiconductor memory -- there is no danger that the contents of record will disappear. Since a big output is obtained as compared with the magnetic-thin-film memory using the anisotropy magneto-resistive effect proposed from the former, the thin film MAG memory using especially the huge magnetic-reluctance (GMR) effectiveness attracts attention in recent years. for example, the Magnetics Society of Japan -- it was shown in VOL.20 and P22 (1996) at drawing 7 -- as -- hard magnetic film HM / nonmagnetic membrane NM / soft magnetism film SM / nonmagnetic membrane NM -- the solid-state memory which made the component the memory device is proposed. Word line W from which it was joined to the metallic conductor by this memory device, and sense line S was insulated with the above-mentioned sense line S by the insulator layer I is prepared respectively, and writes in information by the field generated according to this WORD line current and a sense line current. As specifically shown in drawing 8 , word line W is made to generate the field of the direction which changes Current I with sense ID of a sink current, flux reversal of the hard magnetic film HM is performed to it, and record of a memory condition "0" and "1" is performed to it. For example, as shown in this drawing (a), a forward current is passed, a rightward field is generated, "1" is recorded on the hard magnetic film HM, as shown in this drawing (b), a negative current is passed, a leftward field is generated and "0" is recorded on the hard magnetic film HM. As shown in drawing 9 , read-out of information passes the current I smaller than a record current to word line W, and measures a lifting and the resistance change in that case only for the flux reversal of the soft magnetism film SM. Since resistance differs by the case where they are the case where magnetization of the soft magnetism film SM and the hard magnetic film HM is parallel, and anti-parallel if giant magneto-resistance is used, the memory condition of "1" and "0" can be distinguished by resistance change then produced. The soft magnetism film will consist of facing the right leftward, to a memory condition "1", as shown in this drawing (b), as shown in this drawing (c), it will change from small resistance to large resistance, and if a negative pulse is impressed from forward as shown in this drawing (a), as shown in this drawing (e), as shown in this drawing (d), it will change from large resistance to small resistance to a memory condition "0." Thus, if change of resistance is read, read-out of the information which was not concerned with the magnetization condition of the soft magnetism film SM after record, but was recorded on the hard magnetic film HM is possible, and destructive read is possible.

[0003]
[Problem(s) to be Solved by the Invention] However, the magnetization direction of the magnetic layer which follows on making area of a bit cel small, and it becomes impossible to disregard the anti-field (self-demagnetizing field) produced inside a magnetic layer, and carries out record maintenance will not become settled in an one direction, but the magnetic-thin-film memory of the above-mentioned configuration will be unstable. Therefore, informational preservation could not do the magnetic-thin-film memory of the above-mentioned configuration while it made the bit cel detailed, but it had the fault that it could not be integrated highly.
[0004] In view of these points, in case this invention is made bit cel detailed, it abolishes the anti-field of the magnetic thin film which poses a problem, and it aims at implementation of the magnetic-thin-film memory which made high integration possible. Moreover, it aims at implementation of the magnetic resistance element to which a magnetic-reluctance ratio does not fall even if it makes it detailed.
[0005]
[Means for Solving the Problem] The aforementioned purpose is attained by the following means.
[0006] Namely, the 1st magnetic layer to which this invention has low coercive force by cylindrical on a substrate, The laminating of the 2nd magnetic layer which has high coercive force is carried out through the non-magnetic layer which consists of an insulator by cylindrical, and this 1st magnetic layer and this 2nd magnetic layer have an easy shaft left-handed rotation or in the clockwise direction. By whenever [angular relation / of the magnetization direction of this 1st and 2nd magnetic layer] The magnetic resistance element characterized by different thing to ******** is proposed, and said non-magnetic layer is an aluminum oxide, alumimium nitride, silicon oxide, or silicon nitride, The thickness of the 1st magnetic layer and the 2nd magnetic layer exceeds 100A, and is 5000A or less, The thickness of said non-magnetic layer being 5A or more 30A or less and the coercive force of said 1st magnetic layer are below one half of the coercive force of said 2nd magnetic layer. The coercive force of the 10 or more Oes 50 or less Oe and the 2nd magnetic layer exceeds [the coercive force of the 1st magnetic layer] 50Oe(s), The antiferromagnetism layer is prepared in contact with the non-magnetic layer of said 2nd magnetic layer, and the field of the opposite side, this antiferromagnetism layer and this 2nd magnetic layer carry out switched connection, and magnetization of this 2nd magnetic layer is being fixed, The conductor surrounded by the insulator being formed in the core of the 1st magnetic layer and the 2nd magnetic layer and the coercive force of said 2nd magnetic layer include that the coercive force of the 10 or more Oes 50 or less Oe and the 1st magnetic layer is 2 or more Oes, and is below one half of the coercive force of the 2nd magnetic layer.
[0007] Moreover, the magnetic-thin-film memory device characterized by this invention consisting of the aforementioned magnetic resistance element is proposed, and it includes that the 1st magnetic layer and the 2nd magnetic layer contain at least one sort of elements among Fe, Co, and nickel.
[0008] It is what proposes the record approach of the magnetic-thin-film memory characterized by this invention recording the condition of "0" and "1" by setting the magnetization direction of said 1st magnetic layer to the aforementioned magnetic-thin-film memory device by the field which produces a current according to a sink this current in a film surface and a perpendicular. Moreover, further The playback approach of the magnetic-thin-film memory characterized by detecting the magnetization information on "0" and "1" by measuring sink resistance for a current to the aforementioned magnetic-thin-film memory device at a film surface and a perpendicular is proposed.
[0009] In the magnetic-thin-film memory in connection with this invention, since the magnetic film has closed magnetic circuit structure, it is possible to lose the bad influence by the field, and magnetization information can be saved at stability. For this reason, a 1-bit cell size can be made small and magnetic-thin-film memory with a high degree of integration can be realized. Moreover, since a leakage field does not begin to get wet in a contiguity cel, it becomes possible more to carry out informational record playback to stability.
[0010]
[Embodiment of the Invention] Next, each example of the magnetic-thin-film memory of this invention is explained more to a detail.

[0011]
[Example] (Example 1) Drawing 1 is a memory cell cylindrical in drawing showing an example of the magnetic-thin-film memory device of this invention. In drawing 1 , 1 uses the ingredient which consists of an insulator in order to produce and cheat out of the spin tunnel effect so that the 2nd magnetic layer and 3 may be non-magnetic layers and the 1st magnetic layer and 2 may be mentioned later. Moreover, the arrow head shows the magnetization direction in each magnetic layer. The 1st magnetic layer and the 2nd magnetic layer are cylindrical shapes, it has an easy shaft left-handed rotation or in the clockwise direction, and orientation of the magnetization is annularly carried out along with the cylinder. For this reason, preservation of the magnetization which unlike the medium stated by the Prior art a magnetic pole did not appear in an end face and was stabilized can be performed.
[0012] As for "0" or "1" magnetization information, the magnetization direction of the 1st magnetic layer is recorded corresponding to either the left or right-handed rotation. For example, the 1st magnetic layer has low coercive force so that the magnetization information corresponding to "1" in (b) corresponding to "0" in (a) of drawing 1 can be recorded.
[0013] Orientation is carried out in the direction which the 2nd magnetic layer had coercive force higher than the 1st magnetic layer, and did not depend for the magnetization direction on magnetization information, but was decided beforehand, and it is always kept constant in it also in the state of ******** at the time of playback at the time of record at the time of preservation.
[0014] Moreover, when the magnetic-thin-film memory device of this invention has parallel magnetization of the 1st magnetic layer and the 2nd magnetic layer, low resistance is shown, and high resistance is shown at the time of anti-parallel. For this reason, according to the magnetization direction of the 1st magnetic layer, the resistance of a memory device differs and the recorded magnetization information can be read.
[0015] The huge magnetic resistance element of a spin tunnel mold is used for the memory device of this invention. This is based on the following reasons. The 1st is because a big magnetic-reluctance (MR) ratio is obtained in a spin tunnel mold. By the magnetic resistance element of the spin dispersion mold whose non-magnetic layer of good conductors, such as Cu, was pinched between magnetic layers, although only about 10% of MR ratio is obtained, in a spin tunnel mold, about 20 - 30% of MR ratio is obtained at the room temperature, and the signal at the time of being reading can be enlarged. It is because the magnetic resistance element of a spin tunnel mold can enlarge more than 1kohm and its resistance for the resistance the 2nd. Although this connects and uses a solid-state-switching component for a memory device when arranging the memory device of this invention on a matrix and operating, it is because reading of the information recorded on the memory device becomes unstable in response to the effect of dispersion in on resistance when resistance of a memory device is smaller than the on resistance (about 1 about k ohms) of a solid-state-switching component. It is because the CPP(Current Perpendicular to the film Plane)-MR (Magneto-Resistance) effectiveness of passing a current at right angles to a film surface in a spin tunnel mold can be used for the 3rd. The direction in which a memory device attaches the electrode lines 6 and 7 up and down like drawing 2 like this invention is because contact on a memory device and an electrode line can be taken certainly rather than it attaches a terminal in the longitudinal direction of a memory device, in case this attaches a terminal in a memory device. Although magnetic reluctance can be similarly observed by the CPP-MR effectiveness by the magnetic resistance element of a spin dispersion mold with this point, as a memory device, it is unsuitable. The magnetic resistance element of a spin dispersion mold has it, even when the resistance passes a current in parallel with a film surface, but when using the CPP-MR effectiveness, single or more figures resistance becomes small further, and, as for this, reading is no longer performed correctly as mentioned above. [as small as several 10 ohms]
[0016] (Example 2) As mentioned above, the magnetic-thin-film memory device of this invention is characterized by a magneto-resistive effect arising with a spin tunnel mold. Although the magneto-resistive effect by this spin tunneling makes the structure of the 1st magnetic layer / non-magnetic layer / the 2nd magnetic layer as shown in drawing 1 , it uses a thin insulating layer for a non-magnetic layer. And when a current is perpendicularly passed to a film surface at the time of playback, it is made for

electronic tunneling to occur from the 1st magnetic layer to the 2nd magnetic layer.
[0017] If the ferromagnetic tunnel junction which the electronic states of the upward spin in a Fermi surface and bottom ** spin differ, and the magnetic-thin-film memory device of the spin tunnel mold of this invention becomes from a ferromagnetic, an insulator, and a ferromagnetic using such a ferromagnetic metal since conduction electron has started spin polarization in the ferromagnetic metal is made, in order to tunnel conduction electron, with the spin maintained, according to the magnetization condition of both magnetic layers, a tunnel probability changes, it will serve as change of tunnel resistance and it will appear. Thereby, resistance becomes large when resistance is small when magnetization of the 1st magnetic layer and the 2nd magnetic layer is parallel, and magnetization of the 1st magnetic layer and the 2nd magnetic layer is anti-parallel. Since, as for this resistance, the one where the difference of the density of states of upward spin and bottom ** spin is larger becomes large and a bigger regenerative signal is acquired, as for the 1st magnetic layer and the 2nd magnetic layer, it is desirable to use a magnetic material with the high rate of spin polarization. The 1st magnetic layer and the 2nd magnetic layer select Fe with the large amount of polarization of the vertical spin in a Fermi surface, and, specifically, come to select Co as the 2nd component. It is desirable to choose from the ingredient which specifically used Fe, Co, and nickel as the principal component, and to come to be used, and Fe, Co, FeCo, NiFe, NiFeCo, etc. are good preferably. When elementary composition of NiFe is set to NixFe 100-x, as for x, 82 or less [0 or more] are desirable. More specifically, Fe, Co, nickel72Fe28, nickel51Fe49, nickel42Fe58, nickel25Fe75, nickel9Fe91, etc. are mentioned.
[0018] Furthermore, the 1st magnetic layer has NiFe, NiFeCo, more desirable Fe, etc., in order to make holding power small. Moreover, the 2nd magnetic layer has the desirable ingredient which uses Co as a principal component, in order to enlarge holding power.
[0019] (Example 3) It must be an insulating layer in order that a non-magnetic layer may hold spin in order that the magnetic-reluctance memory device of this invention may use the magneto-resistive effect by spin tunneling, and an electron may tunnel as mentioned above. All of nonmagnetic membranes may be insulating layers, or the part may be an insulating layer. By making a part into an insulating layer and making the thickness into the minimum, a magneto-resistive effect can be heightened further. The example which some aluminum film is oxidized in air and forms 2O3 layers of aluminum as an example made into the oxidizing zone which oxidized the non-magnetic metal film is given. A non-magnetic layer consists of an insulator and it is desirable preferably that they are aluminum-oxide AlOx, alumimium nitride AlNx, silicon oxide SiOx, and silicon nitride SiNx. It is good also considering NiOx as a principal component. Although this requires that a suitable potential barrier should exist to the energy of the conduction electron of the 1st magnetic layer and the 2nd magnetic layer in order for a spin tunnel to occur, it is because it is comparatively easy to obtain this barrier and a manufacture top also has it with an above-mentioned ingredient. [advantageous]
[0020] (Example 4) The thickness of the 1st magnetic layer of the magnetic-thin-film memory device of this invention and the 2nd magnetic layer exceeds 100A, and it is desirable that it is 5000A or less. When this uses [1st] an oxide for a non-magnetic layer, it is the effect of an oxide and the magnetism of the interface by the side of the non-magnetic layer of a magnetic layer becomes weaker, and a large thing is mentioned when this effect of thickness is thin. It is because several 10A of aluminum remains when introducing oxygen, oxidizing it and creating it to it, after forming aluminum for an aluminum-oxide non-magnetic layer to the 2nd, this effect becomes large when a magnetic layer is 100A or less, and a suitable memory property is not acquired. When a memory device is made detailed to especially submicron one the 3rd, the memory maintenance engine performance of the 1st magnetic layer is because the maintenance function of fixed magnetization of the 2nd magnetic layer declines again. Moreover, since it is problems, like the resistance of a cel becomes large too much when too thick, 5000A or less is desirable more desirable, and 1000A or less is good.
[0021] As the 1st magnetic layer 1, on Si substrate, it carried out as NiFe (thickness t) and a non-magnetic layer 3, the laminating of the Co (thickness t) was carried out to order as aluminum 2O3 (10A of thickness), and the 2nd magnetic layer 2, and the magnetic-thin-film memory device of this invention of the configuration of drawing 2 (a) was created. Micro processing of NiFe, aluminum2O3, and the

spin tunnel component section that consists of Co(es) was carried out to cylindrical [with a diameter of about 0.8 micrometers] by the focal ion beam. The magnetic layer thickness t was changed and created from 10A to 10000A. between an electrode 6 and 7 -- a current -- the case where a sink and two magnetic layers are parallel -- anti- -- the resistance in the case, ****, was measured. The (maximum resistance-minimum resistance) / the minimum resistance defined MR ratio. The result was described in the column of the example A of an experiment of Table 1. From 110A, to 5000A, magnetic layer thickness became less than 10% except [its], although MR ratio was 15% or more. Moreover, to 1000A, 20% or more of MR ratio was obtained from 110A.

[0022] (Example 1 of a comparison) Next, the thickness of a magnetic layer was changed like the above, the diameter of about 0.8 micrometers was processed and what constituted drawing 2 (a) from spin dispersion film as an example 1 of a comparison (the laminating of a magnetic layer NiFe (thickness t), a non-magnetic layer Cu (50A of thickness), and the magnetic layer Co (thickness t) was carried out to order) was created. The spin dispersion film is huge magnetic-reluctance film with which the non-magnetic layer pinched between two magnetic layers consisted of good conductors here. The measurement result of MR ratio of this component is shown in the column of the example 1 of a comparison of Table 1.

[0023] (Example 2 of a comparison) next, the thickness of a magnetic layer was changed like the above, the diameter of about 0.8 micrometers was processed and the spin tunnel film (SM in drawing -- NiFe (thickness t) and NM -- aluminum2 -- O3 (15A of thickness) and HM were set to Co (thickness t)) of drawing 7 of the open magnetic circuit configuration which the magnetic path has not closed as an example 2 of a comparison was created. The measurement result of MR ratio of this component is shown in the column of the example 2 of a comparison of Table 1.

[0024] (Example 3 of a comparison) Next, die length of about 0.8 micrometers was processed like the above, the spin dispersion film (NiFe (thickness t) and NM were set to Cu (50A of thickness), and HM was set to Co (thickness t) for SM in drawing) of drawing 7 of the open magnetic circuit configuration which the magnetic path has not closed as an example 3 of a comparison was created, and MR ratio was measured. The measurement result of MR ratio of this component is shown in the column of the example 3 of a comparison of Table 1.

[0025]

[Table 1]

表1

磁性層膜厚 t (A)	MR比(%)	MR比(%)	MR比(%)	MR比(%)
	実験例A	比較例1	比較例2	比較例3
	スピントンネル	スピン散乱	スピントンネル	スピン散乱
	円筒型	円筒型	開磁路	開磁路
10	1	1	1	1
30	5	3	5	3
50	10	5	10	5
90	11	6	11	6
110	20	2.5	11	1.5
150	21	1.1	10	1.1
200	20	1	5	0.5
300	21	0.6	0	0
500	22	0	0	0
1000	22	0	0	0
2000	18	0	0	0
3000	18	0	0	0
4000	15	0	0	0
5000	15	0	0	0
6000	8	0	0	0
7000	8	0	0	0

[0026] Table 1 shows that high MR ratio is obtained, even if the spin tunnel component of this invention has high MR ratio and thickens a magnetic layer especially as compared with a spin dispersion component. Moreover, MR fall of an open magnetic circuit configuration becomes remarkable [magnetic layer thickness] at 100A or more. An anti-field is reduced by having considered as cylindrical, and this is presumed to be because for the turbulence of the magnetization direction to have decreased. However, as for the spin dispersion film, MR ratio is falling [magnetic layer thickness / cylindrical] by 100A or more. By the spin dispersion film, this is because the magneto-resistive effect itself stops being able to occur easily, when magnetic layer thickness becomes thick.
[0027] Therefore, the anti-field reduction by cylindrical becomes remarkable [the effectiveness] from the spin dispersion film in the spin tunnel film. That is, it turns out that the effectiveness is demonstrated with a spin tunnel component, and a cylindrical configuration serves as a device which can respond to high integration.
[0028] (Example 5) Said non-magnetic layer is about several 10A uniform layer, and, as for the thickness of the insulating part, it is desirable that it is [5A or more] 30A or less again. This is because the 1st magnetic layer and the 2nd magnetic layer may short-circuit electrically when it is less than 5A, and when exceeding 30A, it is because electronic tunneling stops being able to occur easily. Furthermore, it is desirable desirably that it is [5A or more] 25A or less. 5A or more 18A is more desirably good.
[0029] (Example 6) The coercive force of the 1st magnetic layer of the magnetic-thin-film memory device of this invention has desirable 50 or less Oes** at 10 or more Oes again. It is because the electrode line which limiting current density is reached and connects a memory device or a memory

device, and a switching element moreover the current which flux reversal takes in the case of the coercive force which exceeds 50Oe in order to reverse magnetization of the 1st magnetic layer by the field which this passes a current to a memory device at the time of record, and is generated in that case becomes large and the power consumption of memory becomes large is disconnected. Moreover, in 10 or less Oes, it is because it is difficult to save magnetization information at stability. Moreover, as for the coercive force of the 2nd magnetic layer, it is desirable to exceed 50Oe. This is because it becomes impossible for magnetization to be able to be reversed and to reproduce it at the time of record at the time of preservation, when coercive force is weak.
[0030] As for the coercive force of the 1st magnetic layer of the magnetic-thin-film memory device of this invention, for this reason, it is desirable to set below to one half of the coercive force of the 2nd magnetic layer.
[0031] What is necessary is to adjust elementary composition x and y, for example as Co100-x-yFexPty, and just to control coercive force, since coercive force will become small if control of coercive force adds Fe to Co, and coercive force will become large if Pt is added. Moreover, since coercive force can be heightened also by making high substrate temperature at the time of membrane formation, it is also good to adjust the substrate temperature at the time of membrane formation as the control approach of another coercive force. This approach and the method of adjusting the presentation of the ferromagnetic thin film mentioned above may be combined.
[0032] (Example 7) In the magnetic-thin-film memory device of this invention, an antiferromagnetism layer may be prepared in contact with the non-magnetic layer of the 2nd magnetic layer, and the field of the opposite side, this antiferromagnetism layer and this 2nd magnetic layer may carry out switched connection, and magnetization of this 2nd magnetic layer may be fixed. Switched connection with an antiferromagnetism layer enables it to enlarge coercive force of the 2nd magnetic layer. In this case, since it is also possible to use the same ingredient as the 1st magnetic layer and the 2nd magnetic layer, in order to enlarge coercive force, it has not said that MR ratio is sacrificed and the width of face of selection of an ingredient spreads. As an antiferromagnetism layer, nickel oxide NiO, iron manganese FeMn, cobalt oxide CoO, etc. are mentioned.
[0033] (Example 8) Drawing 3 is drawing showing another example of the magnetic-thin-film memory device of this invention. The conductor 5 surrounded by the insulator 4 is formed in the core of the 1st magnetic layer 1 and the 2nd magnetic layer 2 by drawing 3 . This conductor 5 is for passing and carrying out flux reversal of the current in the case of record, and what has conductivity higher than a magnetic layer is used for it. An insulator 4 is formed in order to prevent a conductor 5 and a magnetic layer contacting. Drawing 4 is what showed the sectional view of drawing 3 , and adds and shows the word line 7 used in the case of the sense lines 61 and 62 further used for drawing 3 for playback, and record. At drawing 4 , although the sense line 62 is functioning also as a resistance electrode of a word line 71, drawing 5 formed the word line 72 independently. With the structure shown in drawing 5 , it records on word lines 71 and 72 by passing a current in the case of record. At the time of reading, a current is passed between a sense line 61 and a sense line 62, and the resistance of a memory device is measured at it. In addition, even if sense lines 61 and 62 and word lines 71 and 72 are parallel, they may lie at right angles. For example, in the structure shown in drawing 6 , a sense line 61 and a sense line 62 are parallel, and the word line 7 is formed in the form which intersects perpendicularly with it.
[0034] Since a current does not flow to a magnetic layer as compared with the structure of drawing 1 at the time of record, wiring resistance becomes low and is excellent in power consumption and responsibility with the structure shown in drawing 3 , 4, and drawing 5 .
[0035] (Example 9) In case it records on the magnetic-thin-film memory device of this invention, as a current is perpendicularly passed to a film surface, namely, a current becomes perpendicular to a magnetization method, the condition of "0" and "1" is recorded by defining the magnetization direction of said 1st magnetic layer by the field produced according to this current. The sense of the magnetic field to generate changes with sense of the current to pass. For example, when a current is passed downward from on a memory device, it sees from the upper part of a memory device, a field occurs clockwise, and magnetization becomes clockwise. If a current is passed upwards from the bottom on the

contrary, magnetization will become counterclockwise. The 1st magnetic layer of the magnetic-thin-film memory device of this invention has small coercive force, and the 2nd magnetic layer has large coercive force. If it sets up so that a larger field than the flux reversal field of the 1st magnetic layer may generate the magnitude of the current to pass, according to the sense of the magnetization, the digital data of "0" and "1" is recordable on the 1st magnetic layer.

[0036] (Example 10) playback of magnetization information -- the magnetic-thin-film memory device of this invention -- a film surface perpendicular, i.e., the order of the 1st magnetic layer, a non-magnetic layer, and the 2nd magnetic layer, -- or the magnetization information on "0" and "1" is detected by measuring the resistance between the 1st magnetic layer of a memory device, and the 2nd magnetic layer, as it flows in order of the 2nd magnetic layer, a non-magnetic layer, and the 1st magnetic layer. At this time, when the sense of magnetization of the 1st magnetic layer and the 2nd magnetic layer is parallel, resistance is small, and when it is anti-parallel, resistance is large. Since it is fixed in the direction decided beforehand, by the magnetization recorded on the 1st magnetic layer, resistance differs and magnetization of the 2nd magnetic layer can read information.

[0037] (Example 11) Magnetization should just be carrying out orientation of the magnetic layer to the closed magnetic circuit not only with the shape of a cylinder but with structure with a square cross section. For example, the structure which has the cross section of a square as shown in drawing 10 (b) instead of drawing 10 (b) and drawing 3 instead of drawing 1 (a) is sufficient. For the 1st magnetic layer and 2, as for a non-magnetic layer and 4, in drawing 10 , the 2nd magnetic layer and 3 are [1 / an insulator layer and 5] writing rays. Moreover, not only a square but a polygon is sufficient. However, since cylindrical structure turns into most stable closed magnetic circuit structure, it is more desirable.

[0038] (Example 12) Although the magnetization direction used as the fixed layer (pin layer) the memory layer which saves information for the 1st low magnetic layer of coercive force, and the 2nd high magnetic layer of coercive force in the above example, it is good also as a detection layer for reading the information on the 2nd magnetic layer for the memory layer and the 1st magnetic layer which save information for the 2nd magnetic layer. This detection layer carries out flux reversal bidirectionally at the time of playback, and it is prepared in order to detect resistance change produced in that case.

[0039] As for the coercive force of the 10 or more Oes 50 or less Oe and the 1st magnetic layer, with the configuration of a detection layer / non-magnetic layer / memory layer, it is desirable for the coercive force of the 2nd magnetic layer to be 2 or more Oes, and to be below one half of the coercive force of the 2nd magnetic layer.

[0040] (Example 13) Although the above example mainly indicated the memory device, as **** also shows, even if it makes the component of this invention detailed, the point that high MR ratio is realizable is the description. Therefore, you may apply to the magnetic head of not only a memory device but a hard disk, a magnetic sensor, etc.

[0041]

[Effect of the Invention] This invention can realize the highly preservable high degree of integration and the dependability of magnetization information, as explained above. Furthermore, stable rec/play can be performed and it has the effectiveness that the manufacture margin of a non-magnetic layer is large, playback time amount is short, and few playback approaches of a noise can be realized.

[Translation done.]

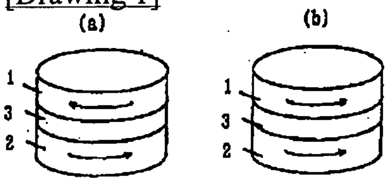
* NOTICES *

JPO and NCIPI are not responsible for any damages caused by the use of this translation.

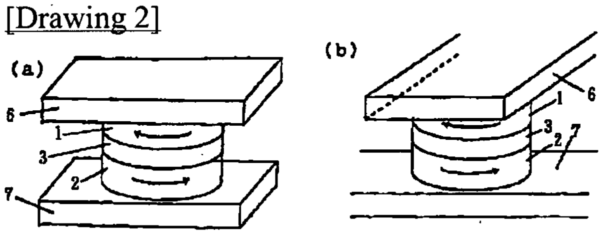
1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

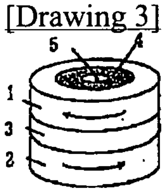
[Drawing 1]



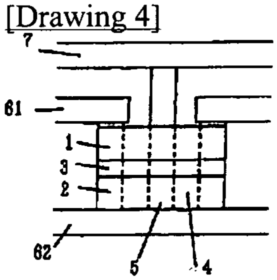
[Drawing 2]



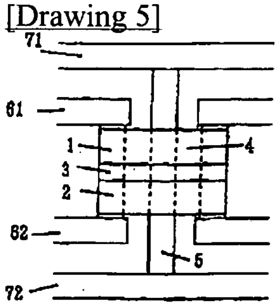
[Drawing 3]



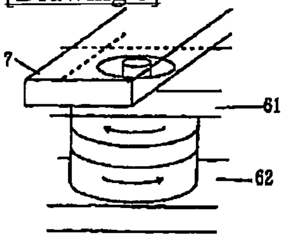
[Drawing 4]



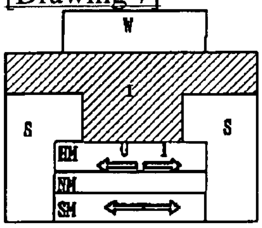
[Drawing 5]



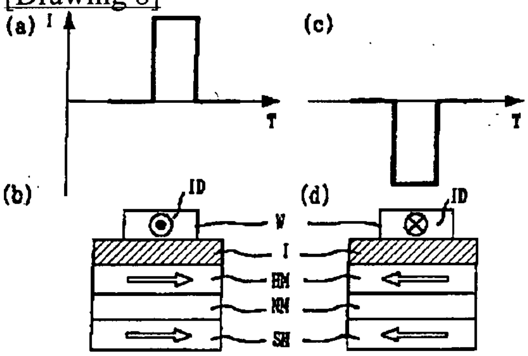
[Drawing 6]



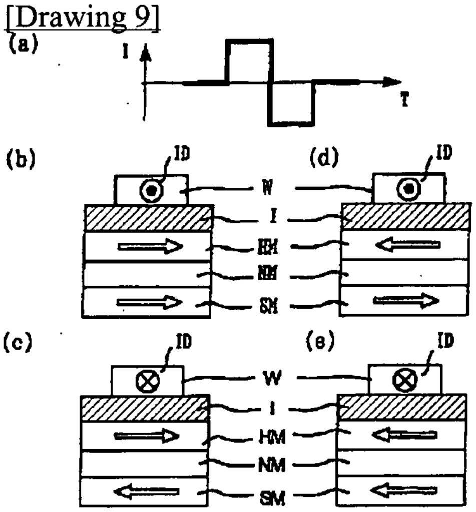
[Drawing 7]



[Drawing 8]

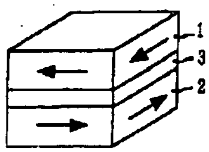


[Drawing 9]

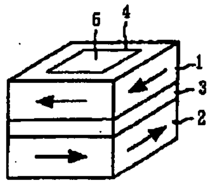


[Drawing 10]

(a)



(b)



[Translation done.]